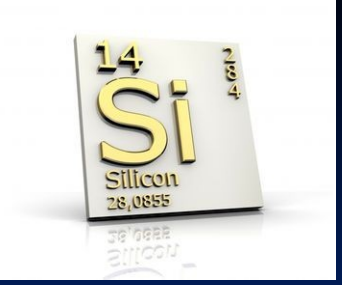
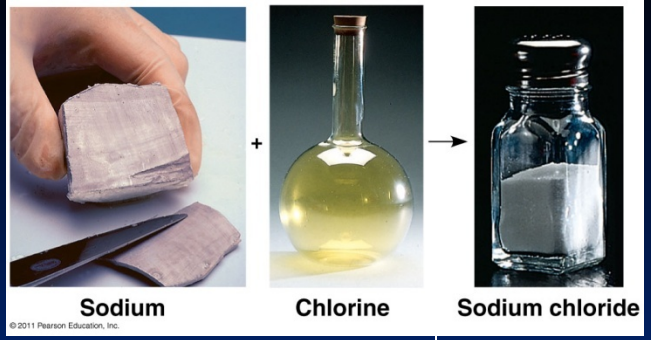
I. Matter vs. Energy

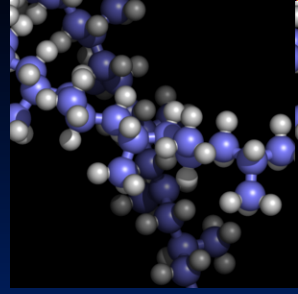
$E = mc^2$

Matter	Energy
Has mass & takes up space	Moves matter
Affected by gravity	Potential, kinetic (based on position)
Consists of elements and compounds	Ability to do work (based on movement)
	Conversions (Gibbs free energy)
	Sound, light, heat





H_2O_2



Element

- "pure" substance
  Based on # of protons
- Can't be broken down by "ordinary" means to another substance
- Ex. hydrogen (H), nitrogen (N)

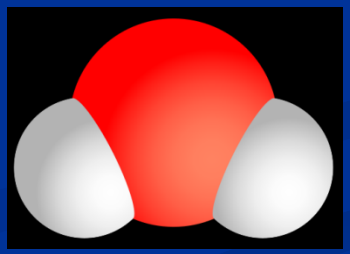
NH_3 N_2
compound element

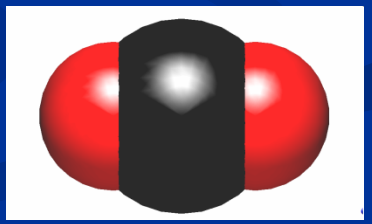
Compound

- 2 or more different elements combined in a fixed ratio
- Ex. H_2O, CO_2

water

O_2 → diatomic element





Elements of Life

- **25 elements** → found in organic materials (118 elements)
  - **96% : O, C, H, N** → O - oxygen, C - carbon, H - hydrogen, N - nitrogen
  - **~ 4% : P, S, Ca, K & trace elements (ex: Fe, I)**
    - Ca → bone

Hint: Remember CHNOPS (phosphorous, sulfur)

why O, C, H, N? water is H_2O

material → macromolecules

≤ fats, proteins, nucleic acids, sugar carbohydrates

Table 2.1 Elements in the Human Body

Element	Symbol	Percentage of Body Mass (including water)	
Oxygen	O	65.0%	96.3%
Carbon	C	18.5%	
Hydrogen	H	9.5%	
Nitrogen	N	3.3%	
Calcium	Ca	1.5%	3.7%
Phosphorus	P	1.0%	
Potassium	K	0.4%	
Sulfur	S	0.3%	
Sodium	Na	0.2%	
Chlorine	Cl	0.2%	
Magnesium	Mg	0.1%	

Trace elements (less than 0.01% of mass): Boron (B), chromium (Cr), cobalt (Co), copper (Cu), fluorine (F), iodine (I), iron (Fe), manganese (Mn), molybdenum (Mo), selenium (Se), silicon (Si), tin (Sn), vanadium (V), zinc (Zn)

macromoles

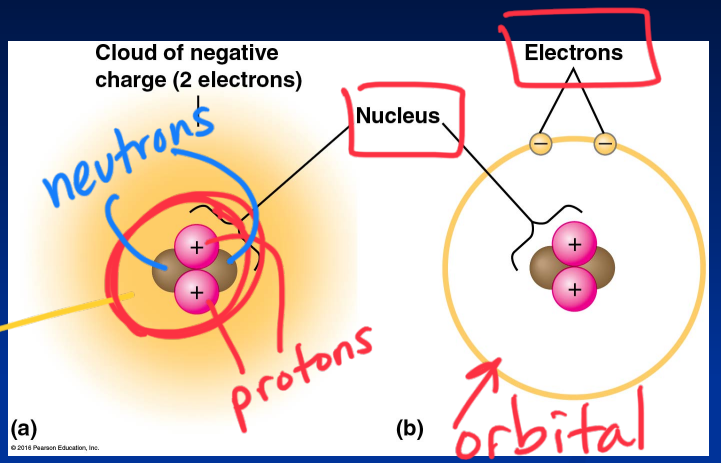
≈25 elements

II. Atomic Structure

matter is mostly space

- **Atom** = smallest unit of matter that retains properties of an element
- **Subatomic particles**:

dense nucleus



	Mass (dalton or AMU)	Location	Charge
neutron	1	nucleus	0
proton	1	nucleus	+1
electron	negligible	shell	-1

relatively big

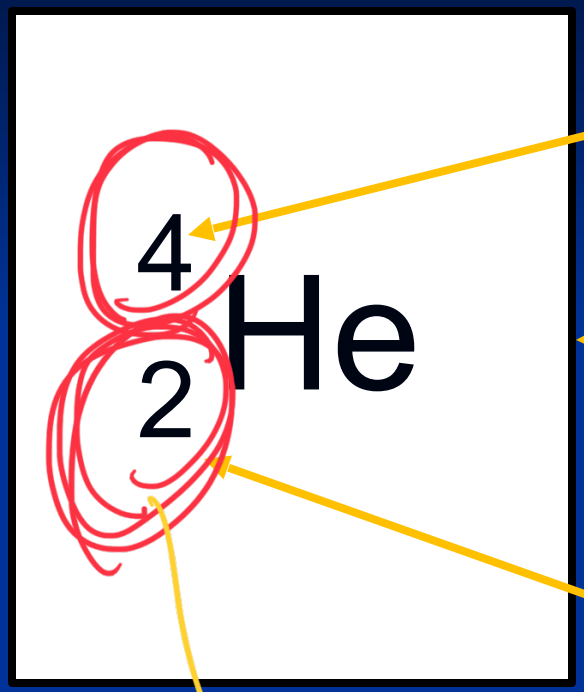
1/2000 of a proton mass

neutral

orbital

Element Helium

Different elements have a different number of protons.



Mass # (protons + neutrons)

symbol

Atomic # (protons or electrons)

# of protons

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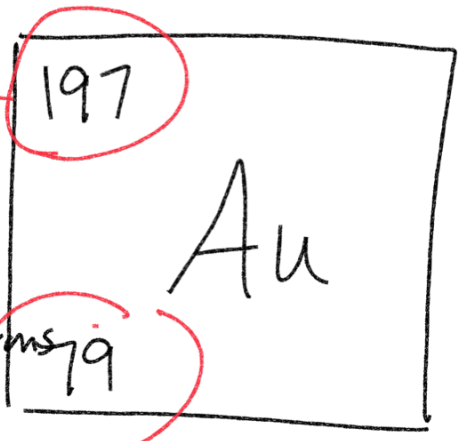
Gold Au



atomic mass

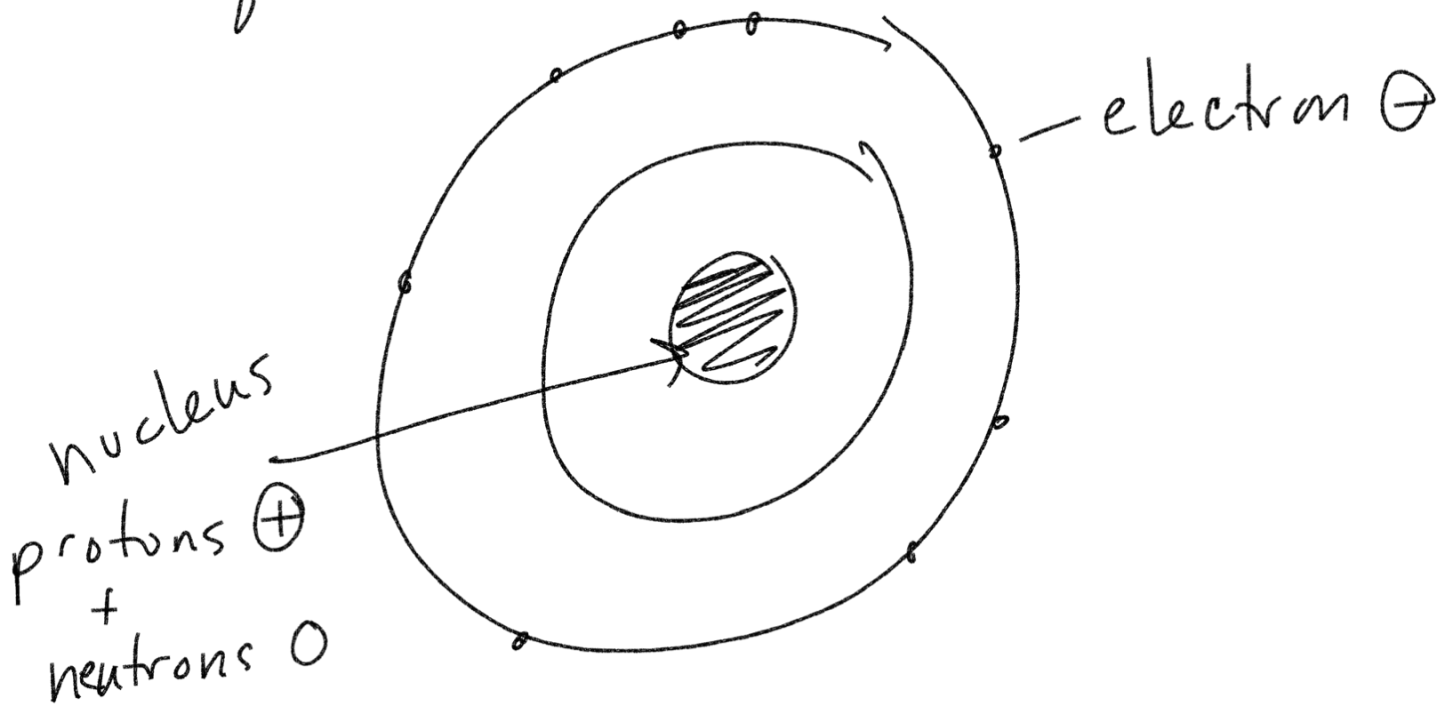
197 − 79 = 118

atomic mass = # of protons + # of neutrons

atomic number = # of protons

protons: 79
electrons: 79
neutrons: 118

In a neutral element, number of protons is equal to the number of electrons



Isotopes

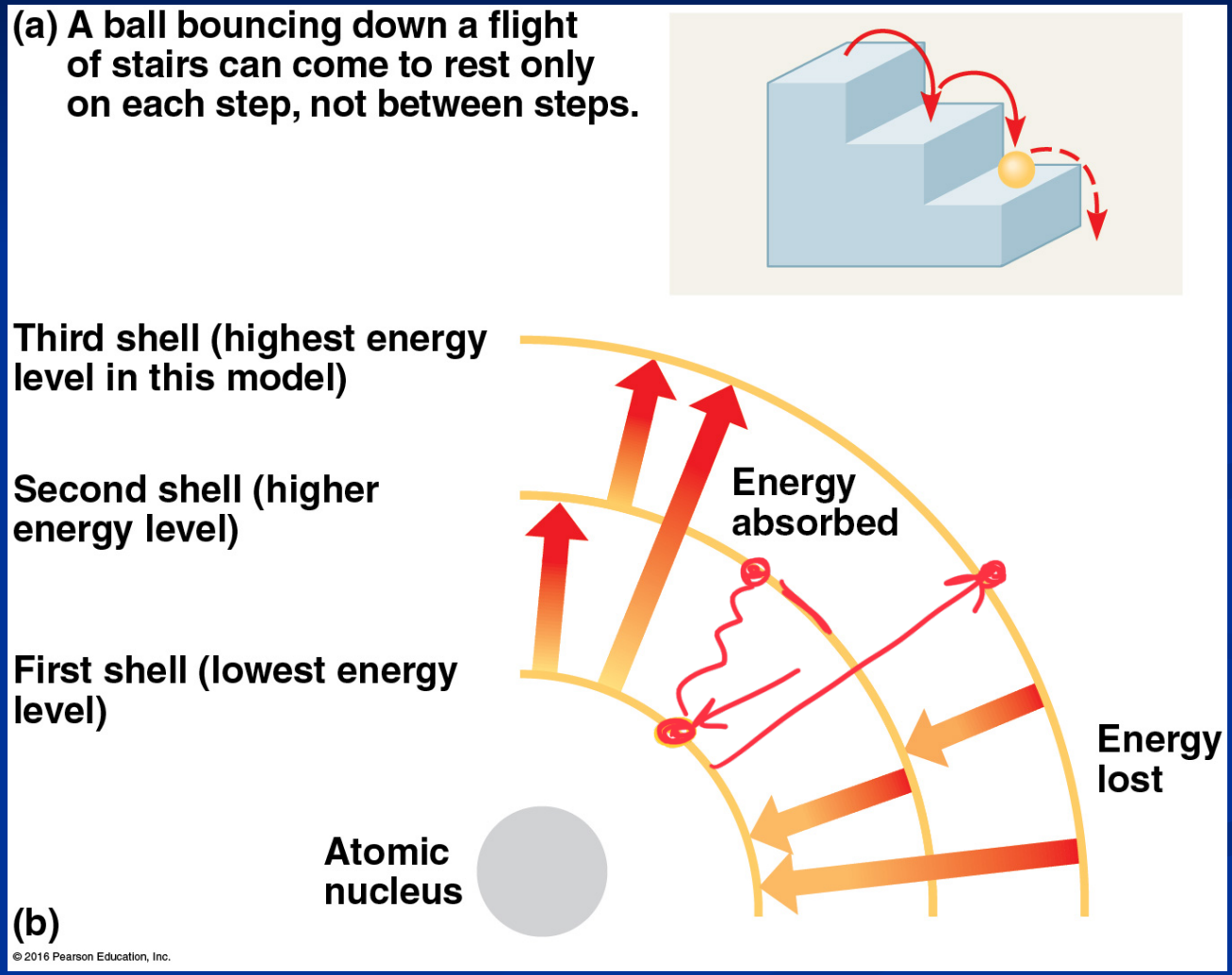
- # neutrons varies, but same # of protons
- Radioactive isotopes used as tracers (follow molecules, medical diagnosis)
- Uncontrolled exposure causes harm

TABLE 2.4 ISOTOPES OF CARBON

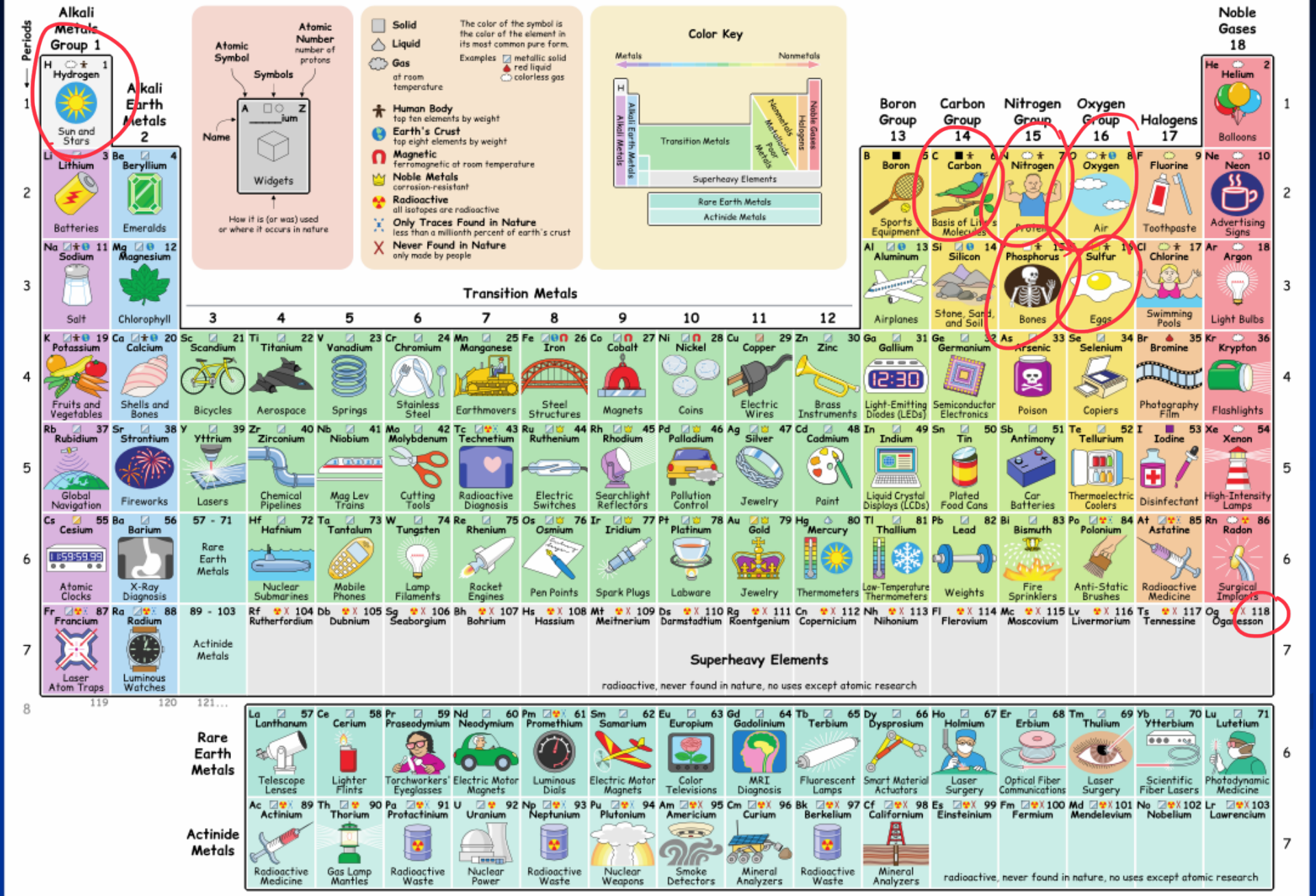
	Carbon-12	Carbon-13	Carbon-14
Protons	6	6	6
Neutrons	6	7	8
Electrons	6	6	6

Electrons exist only at fixed levels of potential energy called electron shells or orbitals

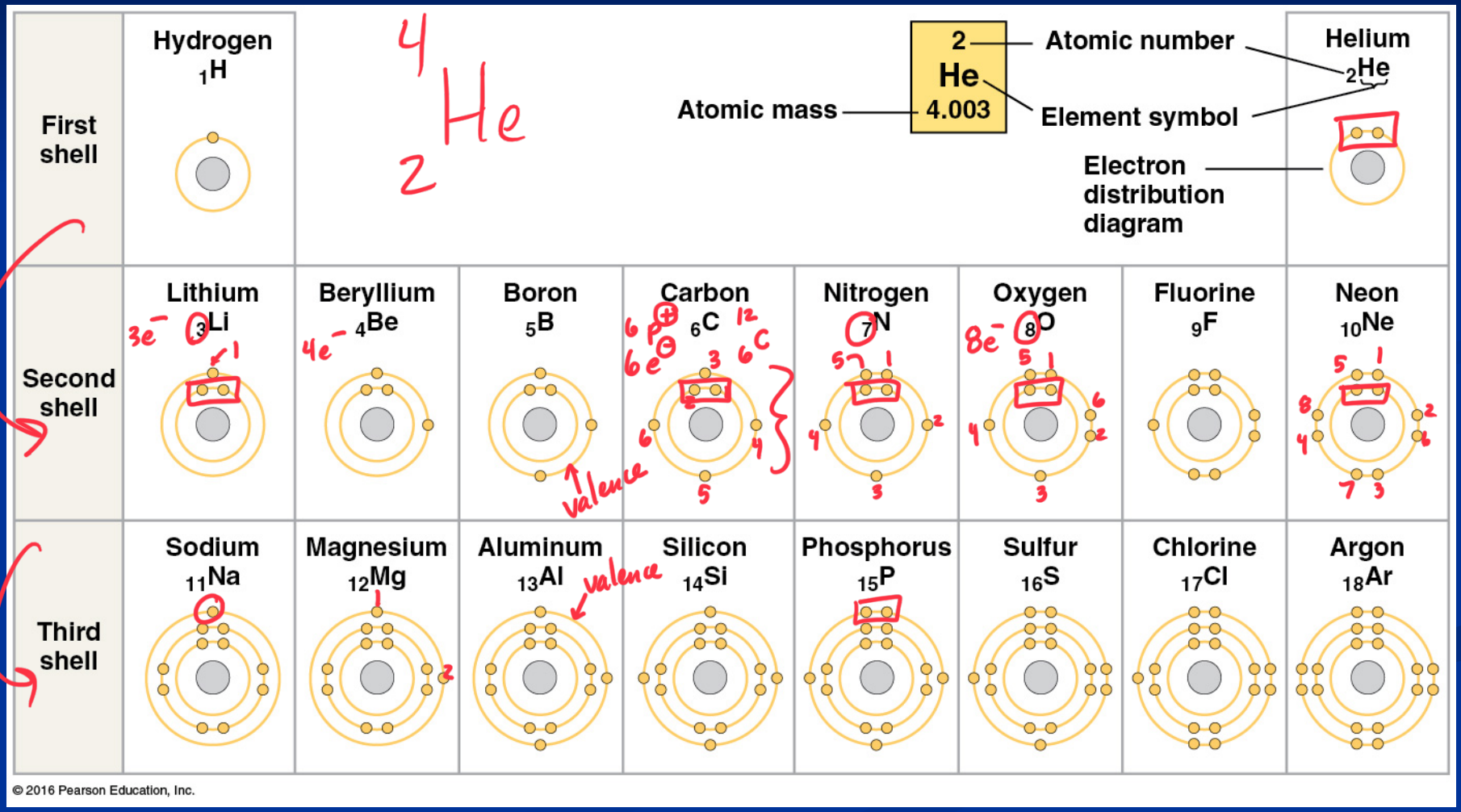
energy exists in small units called quanta



The Periodic Table of the Elements, in Pictures



Valence Electrons



III. Chemical Bonds

outermost orbital or shell is the valence shell

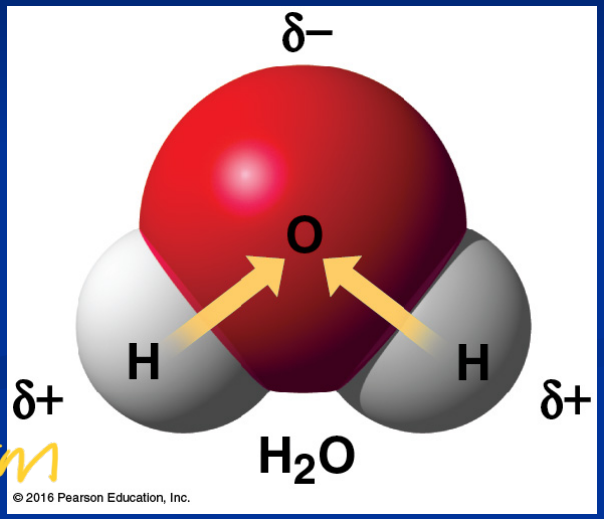
Strongest Bonds:

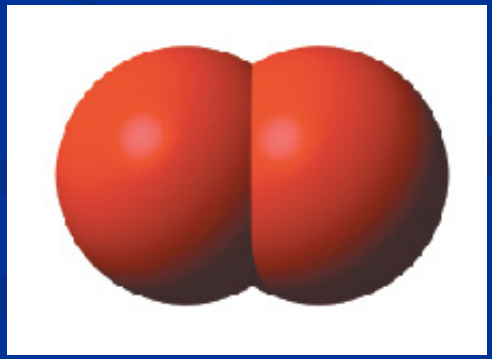
1. **Covalent**: sharing of e-
   - **Polar**: covalent bond between atoms that differ in *electronegativity*
     - Eg. H_20
   - **Nonpolar**: e- shared equally;
     - Eg. O_2 or H_2

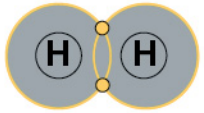
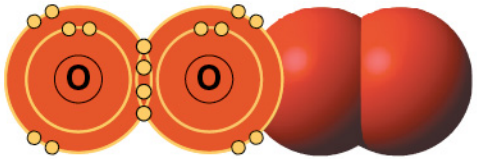
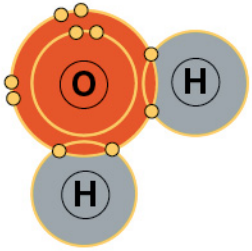
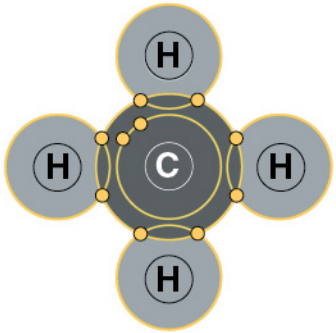
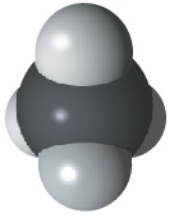
unequal sharing

equal sharing

sharing of outer electrons or valence electron





Name and Molecular Formula	Electron Distribution Diagram	Structural Formula	Space-Filling Model
(a) Hydrogen (H_2)		H—H ← covalent bond very strong	
(b) Oxygen (O_2)		O=O	
(c) Water (H_2O)		O—H | H	
(d) Methane (CH_4)		H | H—C—H | H	

III. Chemical Bonds

noncovalent bonds — do not involve electron sharing

Strongest Bonds:

2. **Ionic**: 2 ions (+/-) bond (givers/takers)
   - Na^+Cl^-
   - Affected by environment (eg. water)